In re Patent Application of:
COFFA ET AL.
Serial No. **09/653,390**
Filing Date: **September 1, 2000**

REMARKS

Applicants would like to thank the Examiner for the thorough examination of the present application.

The claims have been amended to more clearly define the present invention over the cited prior art references. In particular, independent Claims 28 and 38 have been amended to recite a biasing device connected to the doped P/N junction for reverse biasing thereof. This particular feature of the claimed invention is recited in dependent Claims 29 and 40, which are now being cancelled.

The specification has also been amended to correct noted grammatical errors. In addition, Claims 48-54 have been cancelled based upon the restriction requirement. Attached hereto is a marked-up version of the changes made to the claims and to the specification by the current amendment. The attached paper is captioned "Version with Markings to Show Changes Made."

The claim amendments and arguments supporting patentability of the claims are presented in detail below.

I. The Claims Are Definite

The Examiner rejected dependent Claims 30 and 39 as being indefinite. Claim 30 recites that at least one rare-earth material in the depletion layer of the doped P/N junction forms a base-collector region for a bipolar transistor.

The Examiner has taken the position that the P/N junction is part of the biasing circuit. However, Claim 30 only recites that the doped P/N junction forms a base-

collector region for a bipolar transistor. Support in the specification may be found on page 7, lines 14-19, for example. The claims do not recite that the bipolar transistor is part of the biasing circuit. Claim 39 has been amended so that it is similar to Claim 30. Accordingly, it is submitted that Claims 30 and 39 are definite.

II. The Claims Are Patentable Over Benton et al. In View Of Franzo et al.

The Examiner rejected independent method Claims 28 and 38 over the Benton et al. patent in view of the Franzo et al. article. Benton et al. is directed to an optical waveguide system comprising a rare-earth silicon based optical device. Franzo et al. is directed to biasing an Er-doped silicon diode.

The present invention, as recited in independent Claim 28, for example, is directed to a semiconductor device for electro-optic applications comprising a semiconductor substrate, and a doped P/N junction integrated with the semiconductor substrate. The P/N junction comprises a depletion layer and has a shape defining a waveguide. The depletion layer comprises at least one rare-earth material for providing a coherent light source. The semiconductor device further comprises a biasing device connected to the doped P/N junction for reverse biasing thereof.

As discussed on page 9, lines 1-17 in the Applicants' specification, rare-earth ions can be effectively pumped by electron-hole recombination under a forward bias diode operation at temperatures below 200K. However, a

phenomenon know as Auger de-excitation and back energy transfer strongly reduces the efficiency of light emission at higher temperatures. According to the claimed invention, these negative effects are minimized under reverse bias conditions, thereby allowing strong light emission to be achieved at room temperature.

Referring now to the Benton et al. patent, the disclosed optical device includes a rare-earth doped silicon based planar waveguide adapted for guiding or confining electromagnetic radiation of a predetermined wavelength. The optical device also comprises means for causing at least some of the rare-earth materials in the planar waveguide to undergo an electronic transition to an excited electronic state that is associated with luminescence. Reference is directed to column 2, lines 1-9 of Benton et al., which provides:

> "Exemplarily, said causing means comprise means for coupling pump radiation of wavelength $\lambda_p<\lambda_s$ into the waveguide means. However, in preferred embodiments, said causing means comprise means for injection of non-equilibrium charge carriers by means of a forward biased p-n junction or other appropriate injection mechanisms ..." (Emphasis added).

As correctly noted by the Examiner, Benton fails to disclose that the rare-earth doped P/N junction in the optical device may be reverse biased. The Examiner cited the Franzo et al. article as disclosing this feature. The Examiner has taken the position that it would have been obvious to selectively modify the optical device in Benton et al. to

include a reverse biasing circuit instead of a forward biasing circuit.

The Applicants' respectfully disagree. Benton et al. discloses that the bias of the P/N junction is preferably a forward bias. The Applicants' submit that it would not have been obvious to selectively modify the forward biasing circuit in Benton et al. to be a reverse biasing circuit, as recited in the claimed invention. In fact, Benton et al. teaches away from using a reverse biasing circuit by specifically stating that a forward bias circuit is preferred.

It appears that the Examiner is using impermissible hindsight reconstruction to selectively modify the Benton et al. patent in view of the Franzo et al. article to produce the claimed invention. The Applicants respectfully assert that obviousness cannot be established by combining the teachings of Benton et al. and Franzo et al. to produce the claimed invention without some proper prior art teaching, suggestion or incentive supporting such a combination.

Accordingly, it is submitted that independent Claim 28 is patentable over Benton et al. in view of Franzo et al. Independent Claim 38 is similar to independent Claim 28. It is also submitted that independent Claim 38 is patentable over Benton et al. in view of Franzo et al.

III. The Claims Are Patentable Over Benton et al. In View Of Coffa et al.

The Examiner rejected independent method Claims 28 and 38 over the Benton et al. patent in view of the Coffa et al. article. Benton et al. is directed to an optical

waveguide system comprising a rare-earth silicon based optical device. Coffa et al. is directed to the profiling of excited Er in light emitting Si diodes.

The present invention, as recited in independent Claim 28, for example, has been discussed above. In particular, the semiconductor device comprises a biasing device connected to the doped P/N junction for reverse biasing thereof. Reverse biasing allows a strong light emission to be achieved at room temperature.

Referring now to the Benton et al. patent, the disclosed optical device includes a rare-earth doped silicon based planar waveguide adapted for guiding or confining electromagnetic radiation of a predetermined wavelength. As also discussed above, Benton fails to disclose that the rare-earth doped P/N junction is reversed biased. The Examiner cited the Coffa et al. article as disclosing this feature. The Examiner has taken the position that it would have been obvious to selectively modify the optical device in Benton et al. to include a reverse biasing circuit instead of a forward biasing circuit.

The Applicants' respectfully disagree. Benton et al. discloses that the bias of the P/N junction is preferably a forward bias. The Applicants' submit that it would not have been obvious to selectively modify the forward biasing circuit in Benton et al. to be a reverse biasing circuit, as recited in the claimed invention. In fact, Benton et al. teaches away from using a reverse biasing circuit by specifically stating that a forward bias circuit is preferred.

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It appears that the Examiner is using impermissible hindsight reconstruction to selectively modify the Benton et al. patent in view of the Coffa et al. article to produce the claimed invention. The Applicants respectfully assert that obviousness cannot be established by combining the teachings of Benton et al. and Coffa et al. to produce the claimed invention without some proper prior art teaching, suggestion or incentive supporting such a combination.

Accordingly, it is submitted that independent Claim 28 is patentable over Benton et al. in view of Coffa et al. Independent Claim 38 is similar to independent Claim 28. It is also submitted that independent Claim 38 is patentable over Benton et al. in view of Coffa et al. In view of the patentability of independent Claims 28 and 38, it is submitted that their dependent claims which recite yet further distinguishing features of the invention are also patentable. These dependent claims need no further discussion herein.

CONCLUSION

In view of the amendments to the claims and the arguments provided herein, it is submitted that all the claims are patentable. Accordingly, a Notice of Allowance is requested in due course. Should any minor informalities need to be addressed, the Examiner is encouraged to contact the

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Respectfully submitted,

MICHAEL W. TAYLOR
Reg. No. 43,182
Allen, Dyer, Doppelt, Milbrath
& Gilchrist, P.A.
255 S. Orange Avenue, Suite 1401
Post Office Box 3791
Orlando, Florida 32802
407/841-2330

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification:

Paragraph beginning at page 5, line 33 has been amended as follows:

The manufacturing process will now be described step by step. A silicon-on-insulator (SOI) wafer is provided as a substrate 2 for the semiconductor device 1. A known SIMOX or BESOI technology may be used to provide the SOI wafer. However, instead of using [a] an SOI wafer, the substrate for the semiconductor device 1 may simply comprise a double layer of a semiconductor material. For instance, the double layer may include a first highly doped substrate layer and a second upper lightly doped epitaxial layer. In such a case, the lower substrate layer would have a lower refraction index and would act as a reflective layer for the incident light.

Paragraph beginning at page 8 line 25 has been amended as follows:

An additional oxide layer is deposited over the whole semiconductor portion and a masked process is used to define [contacts] contact openings over the P+ region 10 and over the N+ regions 19. A final deposition step of a metal layer, followed by a lithography step, is performed to define the metal contacts on the P+ and N+ regions 10 and 19, as shown in Figure 8. The resulting structure is clearly shown in Figure 9, which is a schematic vertical cross-section and

perspective view of the semiconductor device 1 including a cavity or waveguide and a P/N diode junction.

In the Claims:

The claims have been amended as follows:

28. (Amended) A semiconductor device for electro-optic applications comprising:

a semiconductor substrate; [and]

a doped P/N junction integrated with said semiconductor substrate, said [P/n] P/N junction comprising a depletion layer and having a shape defining a waveguide, said depletion layer comprising at least one rare-earth material for providing a coherent light source; and

a biasing device connected to said doped P/N junction for reverse biasing thereof.

Cancel Claim 29.

38. (Amended) A semiconductor laser device comprising:

a semiconductor substrate;

a doped P/N junction integrated with said semiconductor substrate, said [P/n] P/N junction comprising a depletion layer and having a shape defining a waveguide, said depletion layer comprising at least one rare-earth material for providing a coherent light source; and

a biasing device connected to said doped P/N junction for reverse biasing thereof.

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39. (Amended) A semiconductor laser device according to Claim 38, wherein said [biasing device comprises a bipolar transistor including a base-collector region formed by said doped P/N junction.] at least one rare-earth material in the depletion layer of said doped P/N junction forms a base-collector region for a bipolar transistor.

Cancel Claim 40.

Please cancel Claims 48-54 without prejudice to Applicants' right to file a divisional application directed to the subject matter thereof.